The Synopsis

On

STUDIES OF FABRIC CHARACTERISTICS WITH DIFFERENT WEAVE STRUCTURES

Submitted by

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The Synopsis

Subject	:	**TEXTILE ENGINEERING**
Topic	**:**	**"**Studies of Fabric Characteristics with Different Weave Structures"
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1. **Title of the Research Proposal: Studies of fabric characteristics with different weave structures**

2. **Choice of the topic with reasoning:**

Clothing is an integral part of human life. The primary role of clothing is to form a layer or layers of barriers that protect the body against unsuitable physical environments. This protection of body fulfills number of functions, like maintaining the right thermal environment to the body, which is essential for its survival and preventing the body from being injured by abrasion, radiation, wind, electricity, chemical and microbiological substances. These traditionally classified functions of clothing clearly indicate that it plays a very important role at the interface between human body and it's surrounding in determining the subjective perception of comfort status of a wearer. Today apparel fabrics are expected to meet all requirements related to comfort, health-care and handle and easy-care properties, as well as performance. This has led researchers to develop new materials to provide designers with advanced tools for their specific design. The current trend in industry is towards improved wear comfort. Numerous reports have indicated that most of the queries received by the technologist from the consumers are related in one way or another, to the comfort aspects of the substrates and consequently common intensions are heading in the direction of further improvements.

Woven textiles are designed to meet the requirements of their end use. Their strength, thickness, extensibility, porosity and durability can be varied and depend on the weave used, the thread spacing, that is the number of threads per unit area, and the raw materials, structure, linear density and twist factors of the warp and weft yarns. From woven fabrics higher strengths and greater stability can be obtained than from any other fabric, a structure using interlaced yarns. Structures can also be varied to produce fabrics with widely different properties in the warp and weft directions. The property of any fabric produced depends on the constituent fibres material, yarns and the fabric structure and how all these factors interact with each other. The ultimate aim of any apparel fabric is to satisfy the wearer and make him feel comfortable. Hence in the context, it is worth to study the comfort properties of different weaves in woven fabrics.

Clothing comfort is an extremely complex phenomenon and has drawn the attention of many textile research workers. The present work is, therefore, aimed to optimize the fabric structure

for the apparels with respect to comfort, durability and serviceability properties of fabrics woven on shuttleless weaving machine by using double yarn with 2:1 setting ratio. All the fabrics will be woven with cotton warp and cotton weft. Seven different types of weaves viz. plain, 2/2 matt, warp rib, 3/1 twill, herringbone twill, satin, and crepe will be studied. All the fabrics will be tested before and after finishing. After finishing apparels will be manufactured and characterized for different properties.

3. Literature Review:

3.1 Introduction

In this study, up-to-date work related to the evaluation of fabric hand/handle and comfort has been reviewed. This study focuses on the ways in which researchers have evaluated comfort and other aspects of fabric.

3.2 Factors Influencing Comfort Properties of Textiles

The comfort is considered as a fundamental property when a textile product is valued. The comfort characteristics of fabrics mainly depend on the structure, type of raw material used, weight, moisture absorption, heat transmission and skin perception. The clothing system which is suitable for one climate may not be suitable for another climate, good thermal insulation properties are needed in clothing and textiles used in cold climates. The thermal insulation depends on a number of factors, namely thickness, and the number of layers, drape, fibre density and flexibility of layers and adequacy of closures.

The suitable fabrics from the comfort point of view must be developed by textiles technologist through the proper selection of fibre content, yarn and fabric construction techniques and finishing treatments. The fabric properties depend on fibre properties, yarn structure, fabric structure and the mechanical and chemical finishing given to fabric. The influence of experimental factors i.e. fibre cross section, fibre mix, yarn type and finishing treatment on the thermal characteristics was assessed by Tyagi et al. [1].

3.2.1 Fabric Structure

Fabric structure includes yarn linear densities, sett, weave, crimp levels and can influence critical fabric properties such as cover, thickness, bulk density, mechanical and surface behavior which have a direct relation with fabric comfort.

Boong et al. [2] studied the structural and mechanical properties of woven fabrics using Peirce's model. The study concerns various fabric structures made from different yarns of cotton, wool, and polyester, and weave structures of plain, twill, satin, and matt. Weave structures and fabric relaxation cause changes in the yarn diameter and fabric crimp. Therefore, the diameters of warp and weft yarns in Peirce's model are newly defined to determine effective yarn diameters. When the modified diameters are used to predict the structural and mechanical properties of the fabric, the predicted values show excellent agreement with the measured ones. The more relaxed the fabrics are the more applicable is Peirce's model to predicting fabric thickness and tensile behavior.

Nassif [3] investigated the effects of weft density and weave structures on the physical and mechanical properties of micro polyester fabrics and reported that increasing weft density leads to an increase in fabric breaking load, stiffness, and crease recovery. On the contrary, the increase in weft density decreased air permeability, and tearing strength. The effect of weft density on fabric breaking elongation and abrasion resistance are similar to each other. Plain weave fabrics were superior to other structures in fabric breaking load, breaking elongation and fabric stiffness. Satin weaves have higher air permeability, whereas twill weaves have higher crease recovery.

Effect of fabric weave and weft types on the characteristics of bamboo/cotton woven fabrics was studied by Sekerden [4]. Four different weave type fabrics were produced under industrial conditions by using 100% bamboo of 36.90 tex as the weft yarn, three different mixes of bamboo/cotton and 100% cotton yarn. Unevenness, breaking strength-strain and number analyses were carried out on weft and warp yarns. Tests of dimensional stability, air permeability, water absorption, abrasion resistance and bending rigidity were applied to the fabrics produced. The effect of the yarn and weave types on the physical and mechanical properties of the fabric were examined statistically. It was found that the weave type affects the physical and mechanical properties of the fabric more than the fibre mix and type in the weft yarn.

Matusiak et al. [5] studied the influence of the structure of woven fabrics on their thermal insulation properties. In this work, fabrics of intentionally changed structure were measured in the range of their basic structural parameters and thermal insulation properties. Cotton woven fabrics of different weaves, linear densities of the weft and different weft densities were the

objects of the investigation. Statistical analysis demonstrated that the weave and linear density of weft yarn significantly influence the thermal properties of woven fabrics. A strong and statistically significant correlation was found between the thermal insulation properties of the fabrics and such structural parameters as the average percentage filling and integrated fabric structure factor.

Effect of polyester content, pick density and weave on the thermal comfort and tactile properties of polyester/viscose blended yarn fabrics have been studied by Nayaka et al. [6] by measuring the low- stress mechanical properties on Kawabata evaluation system. The thermal comfort has been studied by measuring the air permeability, thermal insulation and moisture vapor transfer properties of fabrics. The tactile properties have been studied by measuring the fabric mechanical and surface properties, such as tensile, shear, bending, compression, surface roughness, surface friction, and handle. The fabrics with higher polyester content give higher total hand value and higher thermal insulation, but lower air permeability and lower moisture vapor transfer. The fabrics with higher polyester content also show lower extensibility; the extensibility in warp direction is higher than in weft direction and twill woven fabrics give higher extensibility than the plain woven fabrics.

Influence of fabric pattern on the abrasion resistance property of woven fabrics was studied by Kaynak [7]. In this study, the abrasion resistance properties of woven fabrics were investigated as a function of weave type. Seven woven fabrics with different weave derivatives were woven with 100% cotton and 20 Tex (Ne 30/1) combed ring spun yarn for this investigation. These fabrics were tested with a Martindale Abrasion Tester to determine the abrasion resistance property. The abrasion resistance of the fabrics was evaluated according to their mass loss ratio after 4 different cycles (5000, 7500, 10000 and 15000) of the Martindale abrasion testing device. According to data obtained from the test results of sample weave patterns, we observed that the weave pattern has a significant effect on the abrasion resistance property of woven fabrics ($P < 0.01$). Furthermore, it was also noted that the number of rubbing cycles has a significant effect on the abrasion resistance property of woven fabrics ($P < 0.01$). Tukey test results showed that weave types with a high number of floats and a low number of interlacing decrease the abrasion resistance property ($P < 0.05$).

Morino et al. [8] predicted the mechanical properties and hand values from the parameters of weave structure. To promote the design of woven fabrics, the crossing-over firmness factor

(CCF) and the floating yarn factor (FYF) can be defined as the parameters of the weave structures for predicting mechanical properties and hand values. Both the CFF and FYF are related to some mechanical parameters and hand values are derived from those parameters of weave structures, and the predicted values almost exactly agree with the measured values from the KES-FB system.

Dawson [9] studied color and weave effect with some small weave repeat sizes. The derivation of families of color and weave effects from a family of weaves analyzed. All conceivable color and weave families derived from two-color yarn sequences over one weave repeat are identified for repeat size up to 4 x 4. The numbers of effect families realizable with individual weave families vary greatly and tend to be fewer with the more symmetrical weaves. The fewest effect families occur with the 2/2 twill weave family, and all are illustrated. Also examined for each effect family are the number of weave families with which it is realizable, compatible paired of yarn color sequences, and corresponding conditional weave diagrams. Families of effects not realizable for any combination of weave and yarn color sequences are identified. Effect diagrams without rows or column all of one color sequence are shown to be identical to weave diagrams for stacks of unconnected fabrics. Effects with yarn color sequences over several weave repeat are mosaics of those with sequences over one repeat, their number are given for 2 x 2 and 3 x 3 weave families.

Mhetre et al. [10] studied the effect of different weaves and pick densities on thermal properties of fabric. This paper represents varies comfort aspects of woven fabric manufactured with cotton and polypropylene (PP) yarns by changing pick densities and weaves of fabric. In this paper, they have mainly focused on the influence of three different weaves and pick densities on the thermal properties of fabrics. In this paper, they have discussed how these parameters may have contributed to the recognized difference in comfort performance of PP/cotton blend fabrics. Among the yarn known to date, PP & cotton have attached special interest because of better wicking property and less cost of PP & cotton have better comfort properties of the cotton fabric. So this research tries to optimize the fabric parameters to get better comfort with low cost.

Identification of weave patterns by image processing technique was performed by Huang et al. [11]. A new image processing approach was proposed for identifying weave patterns of woven fabrics and automatically displaying harness drafts and chain drafts. Fabric counts are also measured. Based on the maximum and minimum grey level sums of the horizontal and

vertical pixel lines over an entire image, yarns and there cross over an entire image, yarns and their crossover points are located. The decision rules for the recognizing warp and weft floats are developed on the basis of the geometric feature of yarn distribution. The experimental material includes plain, twill, and satin weave, each with 20 samples. Experimental results demonstrate that three basic weaves patterns can be identified. The computer measurement of fabric count shows good agreement with manual measurements.

Haque [12] studied the effect of weft parameters on weaving performance and fabric properties. Threads per inch and yarn count were some of the most important parameters that affect both weaving performance and fabric property. Experimental studies were conducted by weaving fabrics with three different picks per inch (PPI) and weft counts. The study showed that weaving performance was affected by the too high cover factor. Cover factor was calculated by dividing the threads/inch by the square root of the English cotton count and end breakage was taken as an indication of weaving performance. It was observed that when the count as well as threads/inch of one series of yarn changes the crimp% i.e. the consumption of both series of yarns were affected. It was also observed that, as expected, when the threads/inch increase the fabric strength also increases but at higher threads/inch the gain in strength is relatively more. The work reported here shows how the weaving performance and the yarn consumption are affected when fabric (weft) parameters are changed. In this connection, an attempt has been made to study the effect of weft count and picks per inch (PPI) on weaving performance and fabric properties. It is expected that this type of study will be helpful in (i) fixing the cost of woven fabric more efficiently, (ii) generating a better understanding of the weaving process and finally (iii) manufacturing fabric more efficiently from the technical and technological point of view.

Bensaid et al. [13] studied the effect of pattern construction on the tactile feeling evaluated through sensory analysis. Sensory factor is the most important parameters in product quality assessment, and the tactile feeling is one of the most important factors in the case of the fabrics. This new tool has used to study the effect of pattern construction on tactile feeling. Nine different woven fabrics, having the same composition but different patterns, have been selected. The results have shown a considerable effect of the pattern on tactile properties, especially the surface parameters. Some particulars feelings for special patterns have been observed, such as

grooved feeling for waved twill, granular for crepe, and pilous for 12-satin. This study aims to establish a meaningful relationship between fabric qualities and weave structure parameters.

3.2.2 Yarn structure

The yarn structure itself is another important factor in determining fabric mechanical response. For yarns produce from the fibre with a given set of fibre properties, yarn structure governs the yarn properties. Type of yarn like filament yarn, textured yarn and spun yarn produced on the different spinning system, twist level, unevenness, and hairiness have a significant influence on comfort and other properties of fabrics [14].

Tyagi et al. [1] studied the influence of different experimental conditions on the thermal comfort behavior of polyester-viscose and polyester-cotton ring MJS yarn fabrics. The results showed that the yarn structure and the fibre cross-sectional shape have a large influence on improving the thermal comfort of woven fabrics. The fabrics made from MJS yarn performs better than those of the ring yarn fabrics in respects of absorbency, air and water vapor permeability and thermal insulation. Incorporation of non-circular polyester fibre in the mix further improves these characteristics. The chemical finishing treatment also induces noticeable changes in the thermal comfort characteristics of fabrics, though the magnitudes of changes are different for the different ring and MJS yarn fabrics, depending upon processing parameter used. The finished fabric provides enhanced thermal insulation, more absorbency and laser air and water vapor transport than the corresponding gray fabric regardless of the yarn type. Moreover, polyesterviscose fabrics are more promising than the polyester-cotton fabric. For comfort, application expects thermal insulation.

Yang et al. [15] studied the structure and properties of low twist short staple singles ring spun yarns. Low twist singles ring yarns are desirable for their low residual torque, high bulk, and softness, as well as high spinning productivity. However, conventional low twist ring yarns have very low strength and, thus, cannot be used. In this paper, a modification technique is described for producing singles ring yarn with a low twist and a relatively high strength simultaneously. A false twister was used to increase fibre migration and entanglement in the spinning triangle, leading to a reinforcement of yarn strength. The yarns cross-sectional structure, fibre path and yarn surface were evaluated. The results revealed that the modified yarn had a structure and properties different from the conventional ring spun yarns. The fibre path modification was kept in the resultant yarn.

3.2.3 Fibre

Fibre type, fineness, cross-sectional shape, crimp, length, and structural properties are very important for the various properties of fibres. There have been several studied on the comfort properties of the various fabrics [14]. The thermal comfort properties of clothing made from natural and synthetic fibres are determined by the movement of heat moisture and air through it.

Tyagi et al. [1] concluded that polyester-cotton blended fabrics gives higher thermal insulation than polyester-viscose blended fabrics, due to higher thickness. The presence of convolution in the cotton fibre influence the amount of air entrapped and improves insulation. Thus increase in conductivity because of increase in the amount of heat transfer. The increase in cotton content lowers the thermal insulation on account of its higher moisture content. And air permeability decreases with increase in polyester content in the blends due to increase in yarn diameter.

Verdu et al. [16] studied the comfort analysis of woven cotton/polyester fabrics modified with a new elastic fibre. This study aimed to establish the effect of introducing the DOW XLA fibre in woven polyester/cotton fabrics on comfort properties used for professional wear end use. The comfort elements analyzed in this study were thermal and moisture sensations, tactile sensations, and pressure sensations. A fabric elasticized with the elastic fibrepoly butylene terephthalate (PBT) was also included in the study for comparative purposes. This study was also devoted to establishing how the fabric mechanical and comfort properties change with repeated laundry washes (which is denoted here as the maintenance study). The results indicated that the use of DOW XLA fibre inside a core spun yarn to elasticize fabrics for professional wear provided additional comfort over non-elasticized fabrics by adding stretch and an improved hand feel. These fabrics showed a thermophysiological and sensorial comfort that remained constant with washing cycles. The differences in performance found when compared to traditional non-elasticized and PBT-elasticized fabrics were explained as a result of having an elastic fibre in the core of the core spun yarn that had moderated elastic response after yarn and fabric finishing processes.

Detailed study of mechanical, thermo-physiological and skin sensorial properties of woven cotton/polyester fabrics modified with a new elastic fibre was done by Rego et al. [17]. The design parameters studied were the polyester content, the effect of introducing elasticity on the

weft (weft stretch) and the use of fabric treatments and, more specifically, the use of a stain repellency treatment. The comfort elements studied here were the fabric thermal and moisture management properties (thermal resistance, water vapor resistance, water buffering, and wicking and drying rates) and the tactile attributes (four selected Kawabata mechanical properties, three Primary Hand parameters, and the Total Hand). Fabric mechanical properties were also investigated. All properties were modeled using multivariate correlation techniques. The results obtained showed that the weft stretch has a significant influence on tactile comfort as well as on mechanical properties and fabric thermal resistance. The results also showed that polyester content and the application of the functional treatment are the key design elements in controlling fabric performance.

Frydrych et al. [18] studied comparative analysis of the thermal insulation properties of fabrics made of natural and man-made cellulose fibres. Yarn made of natural and man-made cellulose fibres is nowadays commonly applied in textiles. It is already apparent that the type of raw material and fabric structure influences the properties of the finished goods. The main aim of this paper was to present a comparative analysis of thermal insulation properties of fabrics made of cotton and tencel. Six samples of cotton fabrics and nine samples of fabrics from tencel yarn were produced for the purpose of these tests. All fabrics had warp and weft yarns of the nominal linear density of 20 tex. Three kinds of weave were applied: plain, combine and twill weave with nominal warp and weft densities of 320/dm. The measurements were carried out on finished fabric with the use of ALAMBETA device. The results are presented graphically and discussed. The finished fabrics made of tencel yarn showed lower values of thermal conductivity and thermal absorption than fabric made of cotton yarn and higher values of thermal diffusion and resistance. The influence of the type of weave on thermal properties was observed for all fabric made of cotton and tencel.

3.3 Comfort and Fabric Hand Properties

Comfort is related to complex interactions between the fabric, climatic conditions, and psychological variables. A person feels comfortable in a particular climatic condition when his energy production and energy exchange with the environment are evenly balanced so that heating and cooling of the body is within tolerable limits [14].

Many researchers have carried out extensive work on fabric handle properties and comfort properties such as The influence of various design parameters on the performance properties of woven polyester/cotton fabrics for professional wear end-use was studied by Rego et al. [19]. The effect of introducing elasticity on the weft and the use of fabric treatments and the use of a satin repellency treatment. The comfort elements studied here were the fabric thermal and moisture management properties and the tactile attributes. The results showed that the weft stretch has a significant influence on tactile comfort as well as on mechanical properties and fabric thermal resistance.

Ozcelik et al. [20] did study on subjective and objective evaluation of the handle properties of shirt fabrics. It is not possible to measure the handle of fabrics, which can be defined as the total senses felt when touching a fabric. Objectively with only one instrument and therefore in many types of research concerned with fabric sensorial comfort evaluations were done subjectively without using any instruments. However, various instruments and tools have been developed in order to evaluate fabric handle objectively by means of the related physical and mechanical properties. In this study, in order to evaluate fabric, handle of 20 different shirt fabrics objectively, multiple regression analysis was performed, from which both subjective and related objective measurement results were obtained. With an evaluation group consisting of 40 people, the fabrics were evaluated by using bipolar descriptors for the fabric mass per unit area, thickness, bending rigidity, drapeness, as well as the thermal absorption of the fabrics, were measured, from which 16 different parameters were obtained. By using control fabrics, the most appropriate equation was selected among the 10 different regression equations derived.

Efforts were made by Mhetre et al. [21] to produce comfortable fabrics, which should satisfy three conditions that are good hand, the possibility of making the good appearance of the suit and mechanical comfort for wear. Both mechanical comfort and thermal comfort characteristics of the fabric needs to be investigated to understand the physical and physiological interrelationship between the cloth and human body. The present work, therefore, is aimed at studying both mechanical and thermal comfort aspects of PV blended suiting fabrics produced by using different weaves and weft counts in light weight, medium weight and heavy weight categories.

Faizan [22] studied the comparison of fabric properties constructed on shuttle loom and converted loom (Rapier). The construction of fabric can be changed by changing the parameters

which resultantly affects the properties of fabric like comfort, physical and other fabric properties.

Nardo [23] studied comfort properties of five different common apparel textiles. One of the most important properties desired by consumers when they purchase clothing is a comfort. There are various methods for determining the factors that control the comfort of a piece of clothing. Some of those factors are thermal resistivity and evaporative moisture resistivity through the fabric. This thesis investigates the comfort factors of cotton, rayon, polyester, silk and wool fabrics. Fabric parameters such as yarn count, fineness of thread, cover factor, and weight result in different degrees of moisture resistance and thermal resistivity.

Sülar et al. [24] explained the subjective evaluation techniques for stiffness, thickness, and smoothness, which are the components of the handle of suiting, and subjective assessments using these techniques. Another objective of this research was to study the fabric handle of worsted suiting produced in Turkey. For this purpose, a preliminary study was made to determine the words to define fabric attributes used in Turkey. Thickness, stiffness, and smoothness were chosen as the components of the fabric handle of worsted men's suiting. Subjective assessment techniques were developed to assess the chosen attributes. These techniques were applied to 73 fabric samples with the help of an expert jury. The concordances of the subjective test results were investigated by the Kendall concordance test and correlation analyses were carried out to examine the relations between the subjective test results. The assessment of the fabrics by the jury using the techniques was in good agreement. A total handle of 100% wool and wool/polyester blend worsted men's suiting produced in Turkey has a grade of 3.47 on a five-point rating scale. A database was prepared for the handle of worsted men's suiting produced in Turkey.

Rehim et al. [25] have concluded in research work that, in recent times, a wide range of textile materials has been used as thermal insulators in many industrial applications. The thermal insulating properties of textile fabrics depend on their thermal conductivity, density, thickness and thermal emission characteristics. Experiments have been made with the aim of studying heat transfer by conduction through the different types of fabrics used as thermal insulators. 100% polyester and 100% polypropylene nonwoven fabrics are used in this work as case studies. The temperature variation through the selected fabrics is measured under different operating parameters such as densities and inlet temperature. The thermal response and behavior for the

selected fabrics used in this work as thermal insulators are illustrated. The relationship between the thermal conductivity and material density of the selected fabrics is studied. Polyester fabric has higher thermal resistance and specific heat resistance than polypropylene. Fabric thickness has a significant effect on the fabric temperature variations. The results of ANOVA-two-way measurements are presented for 100% polyester and 100% polypropylene nonwoven fabrics. The temperature variation of the fabric increased with the testing time, and also decreased with the increase of fabric weight up to a certain limit beyond its optimum level. The results show that the selected nonwoven fabrics are suitable for usage as thermal insulators.

Sharabaty et al. [26] studied moisture transport through polyester/cotton fabrics. The wettability characteristics of different cotton, polyester, and multi-layered cotton/polyester fabrics have been studied to manage human perspiration well. The vertical capillary action behavior of these fabrics has been compared by measuring the capillary height as a function of time. Wicking coefficient in multi-layered fabrics is found to be much better than in other fabrics of 100% cotton. The yarn and the bonding weave between the two layers are very important for the capillary rise. The objective of this investigation is to study the wettability characteristics of cotton, polyester and cotton/polyester multi-layered fabrics.

Wang et al. [27] evaluated wool shirt comfort with wear trials and the forearm test. The comfort of light-weight woven fabrics in the form of next-to-skin clothing is investigated by wear trials and the forearm test. The wear trial in neutral environmental conditions shows that light-weight wool and wool blended fabrics are generally less comfortable than the summer polyester, cotton poplin, and polyester/cotton fabrics tested in this study. In terms of comfort, the main shortcoming of these light-weight wool fabrics is prickle. When the environmental temperature is high, especially when the body is sweating, the comfort of wool and wool blend fabrics is greatly reduced due to significantly increased prickle. The forearm test in neutral environmental conditions shows that fabric-evoked prickle decreases with an increasing wool quality number, i.e. as the wool becomes finer. For light-weight wool and blend woven fabrics produced from 70s quality and coarser wools, there is the potential problem of prickle when used as nest-to-skin clothing materials.

Matsudaira et al. [28] studied the effect of weave density, yarn twist, and yarn count on fabric handle of polyester woven fabrics by objective evaluation method. Systematic research works were carried out to clarify the effects of weave density, yarn twist, and yarn count on

fabric handle of polyester fabrics made for the purpose, and quantitative influence was clearly shown. These results could provide useful information to design ideal fabrics having a desirable handle.

Tarafder [29] evaluated the properties and clothing comfort. The term comfort may be defined as the absence of unpleasantness or discomfort or a natural stat of comparison to the most active state of pleasure. Sensorial comfort is a perception of clothing comfort which is sensory responses of nerves ending to external stimuli producing neurophysiological impulses which are sent to the brain. The true area of contact between the textile material and other surfaces represents a complex parameter in which many factors play interactive and dependent roles. The influence of the area ratio on the mobile interaction between the fabric and the skin is also investigated. A fabric hand or handle depicts the way a fabric feels when it is touched by human hand and gives an indication of the texture of the fabric. The perception-analysis process attempts to seek out the wearing condition that produces a difference in human sensation and descriptions used by individuals to describe the sensations. This paper highlights the properties of comfort clothing.

Dasa et al. [30] studied the frictional characteristics of woven suiting and shirting fabrics. Frictional characteristics of woven shirting and suiting fabrics with different blends and constructional parameters have been studied. Fabric-to-metal surface and fabric-to-fabric frictional characteristics in both warp-warp and weft-weft directions have also been studied. It is observed that the normal load and the frictional force follow the logarithmic relationship for all the fabrics. The nature of fabric friction has been characterized by different parameters, like the ratio of frictional force to normal load, friction index, friction parameter and their ratio. Fabric-to-metal friction is found to be less sensitive to fabric morphology and rubbing direction, whereas the fabric-to-fabric friction is highly sensitive to these factors. Fabric-to-fabric friction has been affected by a lot of factors, like the type of fibre, type of blend, yarn structure, fabric structure, crimp, compressibility, etc. For all the fabrics, the kinetic friction is always lower than the static friction at different levels of normal load and the F/N ratio reduces consistently with the increase in normal pressure.

Mukhopadhyay et al. [31] studied the comfort properties of polyester-viscose blended fabrics of two different structures (plain and twill). It is observed that with the change in polyester content, the total hand value (THV) of twill woven fabrics shows a different trend than

that of plain woven fabrics. The thermal insulation and water-vapor resistance increase with the increase in polyester content. It is found that the fabric having the best THV may not be comfortable in all aspects.

Mechanical and surface properties were determined for polyester, cotton, and polyester/cotton blend knit fabric by Yoon et al. [32]. The polyester fabric showed an intermediate resistance in accordance with the blend fabrics showed an intermediate efficiency of polyester fibres, resulting in a yarn with a higher modulus. In contrast, the trend was reversed in bending and lateral deformation behavior. This is postulated to be related to higher residual stress in the fabrics due to the different creep behavior of cotton fibres. The compression behavior, friction behavior, and contacting surface fibre counts all point to increasing numbers of surface fibres with increasing cotton content in the fabrics, however, the 50/50 polyester/cotton blend fabric showed almost an identical behavior to the 100% cotton fabric, as was the case with transport properties. Results on various mechanical and surface properties of polyester/cotton blend knit fabrics are summarized in this report, including mechanical properties such as tensile properties, bending properties, handle modulus, and compression properties, and surface characteristics such as friction properties and surface fibre count.

Thermal comfort is associated with changes in many physiological and environmental variables, stated Patil et al. [33], who discuss the mechanism of thermal comfort and fabric properties like insulation, moisture vapor permeability, waterproofing and processes involved in moisture transmission through textiles, concluded that the human body continuously produces heat by its metabolic processes. The heat is lost from the surface of the body by convection, radiation, evaporation, and respiration. In a steady-state situation, the heat produced by the body is balanced by the heat lost to the environment. If not, the body temperature will increase and the human feels uncomfortable.

Human thermal comfort depends on the metabolic rate, the heat losses from the body and the climatic condition. As is well-known, the clothing properties like insulation, moisture vapor permeability, waterproofing are affected by these parameters. Clothing reduces the body's heat loss. Therefore, clothing properties are very important for human thermal comfort.

Shirbhate et al. [34] discussed various instruments and methods for thermal comfort evaluation. The important properties for maintaining thermal comforts are insulation, wind proofing, moisture vapors permeability and waterproofing.

3.4 Interpretation of Weaves

3.4.1 Introduction

To assess the properties of fabric with different weaves or to compare different weaves independent of other factors, we have to interpret fabric design in one common index. Hence to have a clear idea about weave or fabric design, it can be interpreted by the following two factors viz. index of interlacement and average float. The details of both the parameters were discussed in brief in following points.

3.4.2 Index of interlacement

Index of interlacement is the ratio of a number of actual interlacements per repeat to the number of possible interlacement per repeat. A number of possible interlacement per repeat can be calculated theoretically. The formula for index of interlacement is given by:

$$\text{Index of interlacement (I)} = \frac{\text{No. of actual interlacement per repeat (A)}}{\text{No. of possible interlacement per repeat (P)}}$$

3.4.3 Average Float

An average float is a number that accounts for the number of interlacement of warp and weft in a given repeat

$$\text{Average Float (M)} = \frac{\text{No. of threads per repeat (E)}}{\text{No. of intersections per repeat of the cross thread (I)}}$$

The weave interlacing patterns of warp and weft yarns may be different in such cases. The average float is calculated separately with suffixes 1 and 2 for warp and weft respectively. Therefore, $M_1 = E_1/I_2$; and I_2 can be found by observing individual pick in a repeat and $M_2 = E_2/I_1$; and I_1 can be found by observing individual warp end in a repeat. For example:

Plain weave is represented as 1/1; for this weave, E_1 the number of ends per repeat is equal to 1+1= 2 and I_2 the number of intersection per repeat of weft yarn = 1 + the number of changes from up to down (vice versa) = 1 + 1 = 2. A fabric design can be interpreted by two factors, interlacement, and float, for any fabric structure as the interlacement per repeat increase the float decreases. The plain weave fabric shows minimum float and highest index of interlacement. In a 1/1 plain weave, the ends and picks floats over one thread causing each float to be surrounded (tightened) by four interlacing points. Therefore, the plain weave is rigid, tight in construction with no empty spaces and higher compactness in structure as compared to other weaves.

Satin and herringbone twill weave with maximum float and lowest Index of interlacement with M=4 and I=0.25 respectively which makes the fabric less compact as compared to remaining weaves. As these fabrics are much more flexible, these fabrics will drape down by buckling into folds that stiff fabric like plain. While weaves like warp rib, 3/1 twill, matt and crepe display the middle range because these fabrics have an index of interlacement lower than plain but more than satin, and herringbone twill. These fabrics are less stiff as compared to plain fabric but stiffer as compared to satin and herringbone twill.

3.5 Finishing of fabric

Finishing which affect the properties of the fabrics and appearance can also significantly change the performance of fabric in clothing [14]. Wherever possible it is preferred in the textile industry to modify fabric properties by the menace of topical finishes. Finishing is an extremely complex subject because of a large number of changes that occur in fabric properties during finishing sequence. The effects of many finishing operations are interactive. By using various finishing treatments different kind of end products can be produced from the same unfinished woven or knitted fabrics [35].

3.5.1 Singeing

Yarn after spinning contains a considerable proportion of protruding fibres and this is known as hairiness in the yarn. In order to obtain a clean surface of the fabric, it is essential to remove these protruding fibres. If these fibres are not removed, they act as capillaries in coloration and spoil the appearance of the dyed fabrics. In the case of white mercerized fabrics, they mask the luster of the fabric. Another disadvantage of these fibres is the harsh feel that the fabric attains on finishing particularly after starch finishing. The removal of these fibres is carried out by the application of heat with the result that the fibres are burnt off. The process is known as Singeing. There are three types of singing machines employed to active the above objects.

1. Plate singeing machine
2. Roller singing machine
3. Gas singeing machine

3.5.2 Bleaching

The object of bleaching is to remove the natural coloring matter present in the cotton. So by the process of bleaching can increase the whiteness and also simultaneously can decrease the yellowness of cotton fabric.

Classification of Bleaching Agents

1. Reactive bleaching
2. Oxidative bleaching
    a. Peroxide system
    b. Chlorine System

Bleaching treatments are applied to eliminate any impurity and obtain a pure white tone, to prepare substrates for low-density dyes or prints and to level off undesired tone variations. Bleaching agents mainly used for cellulosic fibres are sodium hypochlorite and hydrogen peroxide. They both require the addition of sodium hydroxide in the bleaching liquor to make it alkaline it by favoring the formation of the bleaching ion, which in the first case is the hypochlorite ion and in the second one is the perhydroxylion.

3.5.3 Mercerizing

This is a typical treatment for cotton yarns and fabrics, which improves the fabric luster and wet ability, ensures a covering effect for dead cotton, and improves dimensional stability and dyeing efficiency. This treatment is carried out by using caustic soda, which determines the contraction and swelling of the fibres; they become translucent and increase their tensile strength, but reduce their flexural and torsion strength. The bean like section of the fibre becomes first elliptical then circular, allowing a better reflection of light with a consequent increase of luster.

3.5.4 Finishing

The word, textile finishing, defines a series of processing operations applied to grey fabrics to enhance their appearance and hand, properties and possible applications. The term, finishing, includes all the treatments applied to grey fabrics such as scouring, bleaching, dyeing or printing while we will use the term. Functional finishing, with reference to all the mechanical or chemical finishing operations, carried out on fabrics already bleached, dyed or printed to further enhance

their properties and possibly add some new ones. In the finishing treatment fabric will be treated in the resin finish for wrinkle resistance and easy care properties.

Mehata et al. [36] studied the effect of construction and weave on some mechanical properties of untreated and resin-treated cotton fabrics. The analysis of fabrics of different woven constructions made from the same count of yarn indicates that the different woven construction made from the same count of yarn indicates that the mechanical properties arise mainly from weave differences. Increases in flex abrasion are compensated by a decrease in tear strength and vice versa. The analysis reveals that the initial properties of the twill weave are more balanced for higher levels of crease recoveries than those of the other fabrics. Twill-weave fabrics show high tensile strength. While basket-weave fabrics give higher tear strength, the plain-weave fabrics are best suited for high flex abrasion resistances. After resin treatment, higher initial properties of the weave results in fabrics with improved mechanical properties. In this paper some of the mechanical properties of variously constructed fabrics before and after resin finishing have been examined. The paper also highlights the advantages of retaining high initial crease recovery.

Grant et al. [37] studied the effect of tension and resin-treatment on properties of scoured and mercerized cotton fibres and fabrics of different constructions. Several investigators have reported research results to illustrate the effects of single parameters in a resin treating procedure on the physical properties of fibres, yarns, and fabrics. In the single-system analysis of data, many structural changes are taking place, and their interactions and influences on the physical properties of the treated fabric are neglected. As a result, the applicability of the conclusions to other fabrics or to other fabrics or to other environments is frequently speculative. This report gives some of the related changes in fibres and fabrics when the same resin is applied at different levels and under different mechanical conditions. Fabrics of print cloth weight in plain and basket weave were cross linked with dimethyl ethylene urea to 2, 5, and 10 % add-on. Specimens were dried slack or under tension before curing. By controlling resin pick up, the amount of cross-linking produces reasonably consistent nitrogen contents in samples by varying other parameters. Among the properties measured were fibre density, fabric thickness and area changes, fabric tensile and wrinkle recoveries, and single fibre tenacity and tensile recovery. Relationships of properties to nitrogen contents and among various physical properties were frequently influenced by tension, fabric construction, and pretreatment.

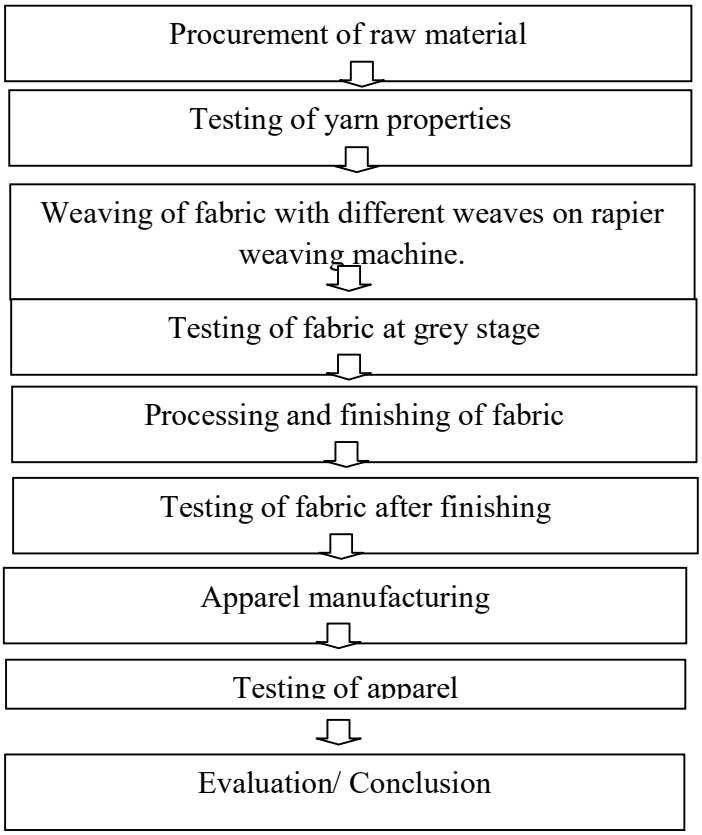
Ruttiger [38] studied the finishing effect on cotton on the basis of a padding weave, and cross-linking function. Up to now, there has been a lack of a physical-chemical function which would establish a link between the formulation of a procedure for a conventional wash-and-wear finish and the properties of the finished fabric after it has been given a household laundering. It appeared responsible to work out a general function, provide excessive accuracy was not called for. This function was arrived at by coordinating both precisely defined and approximate expressions. The amount of cross-linking agent taken up can be calculated from the given formulation and padding data by means of the improving function. The diffusion processes which occur during contact with the liquor and which can be ascertained theoretically only with great difficulty can be represented by an experimentally determinable integrated factor, the exchange coefficient. The attainable degree of finish for cotton, i.e. the crease recovery angle, can be determined by means of the cross-linking function, taking into account the yield of the condensation reaction and the loss in strength. The experimental basis and the range of validity of this function and its dependence on the nature of fabric are dealt with in detail. Finally, the self-smoothing effect can be given in relation to household laundering methods employing empirical conversion curves.

4. The Methodology:

4.1 Introduction

This investigation focuses on the various comfort, durability and serviceability characteristics of different weaves structures, woven by using double yarn with 2:1 setting ratio on a shuttleless weaving machine (which m/c ??). Total seven different types of weaves viz. plain, 2/2 matt, warp rib, 3/1 twill, herringbone twill, satin and crepe will be studied to investigate the comfort and other properties. Cotton yarn will be used in warp and weft for all weaves. Finishing treatments will be carried out on fabric. All the fabric specimens in grey as well as in finished condition will be tested in standard atmospheric conditions for properties like areal density, thickness, air permeability, drapability, crease recovery, abrasion resistance, tearing strength, bending modulus, thermal properties and liquid transport properties. Apparels will be manufactured using finished fabric and tested for different properties. After testing the results will be statistically analyzed .The sequence of the work, materials used, the methodology adopted and various testing procedures are given below.

4.2 Sequence of work


Procurement of raw material
Testing of yarn properties
Weaving of fabric with different weaves on rapier weaving machine.
Testing of fabric at grey stage
Processing and finishing of fabric
Testing of fabric after finishing
Apparel manufacturing
Testing of apparel
Evaluation/ Conclusion

4.3 Materials

100% cotton yarn will be used as warp and weft for all the fabric specimens.

4.4 Methodology

After the procurement of yarn, all yarns will be tested for different properties such as linear density (count), single yarn strength, hairiness, unevenness and level of twist. After testing, fabric with double yarn in warp and weft with ends and picks having 2:1 sett ratio will be manufactured on rapier weaving machine with different weaves. The grey fabric will be processed and finished. Testing of grey as well as finished fabric will be carried to find out different fabric properties. Apparels will be manufactured using finished fabric and will be tested. The fabric and the apparel giving significantly better properties will be determined.

4.4.1 Fabric Manufacturing

Fabric samples with double yarn in warp and weft having 2:1 set ratio i.e. 120 ends per inch and 60 picks per inch will be manufactured on a rapier weaving machine. The variable factor will be fabric weave. Fabrics with seven different types of weaves will be woven on a rapier weaving machine. Weaves include the basic weaves like plain, 3/1 twill and satin along with their derivatives like 2/2 matt, warp rib, herringbone twill and crepe.

The 100% cotton yarn will be used in warp and weft for all the fabric specimens. Seven fabric specimens will be manufactured and finishing treatment will be given to these specimens.

All the grey as well as finished fabric specimens will be characterized for different properties.

4.4.2 Fabric Processing

All the manufactured fabric samples will be subjected to finishing treatments.

4.4.3 Testing

All the manufactured fabrics will be tested according to various standards like ASTM, DIN, AATCC and IS standards to determine different fabric properties. Table 4.2 exhibits the test to be carried out on fabric and their corresponding standards.

Table 4.2 Test Standards

Sr. No.	Test	Standard
1	Areal density	ASTM D3776
2	Thickness	ASTM D 1777
3	Air permeability	ASTM D737
4	Drapability	ASTM D4032
5	Stiffness	ASTM D1388
6	Wicking Behaviour	DIN 53924
7	Drop absorbency	AATCC TS-018
8	Thermal conductivity	ASTM 1518
9	Thermal insulation	-
10	Fabric strip strength	ASTM D5035
11	Tearing strength	ASTM D1424
12	Abrasion resistance	ASTM D4966
13	Crease recovery	IS6359

4.4.4 Apparel manufacturing

All the finished fabrics will be used in apparel manufacturing (formal shirts).

4.4.5 Apparel Testing

All the apparels will be tested for seam strength, fusing bond strength, button pull strength, and visual appearance.

4.4.6 Statistical Analysis

After testing, the obtained results will be analyzed statistically and conclusions will be drawn.

Time line required to carry out research work

Sr. No.	Proposed Work	Time (Months)
1	Literature Survey	03
2	Experimental methodology	03
3	Procurement and testing of the material	03
4	Actual project work	06
5	Testing work to be carried out	03
6	Analysis of the data collected	03
7	Data analysis and thesis writing	03

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